LEITNERIA FLORIDANA.

BY WILLIAM TRELEASE.

While collecting in the lowlands of southeastern Missouri, in November, 1892, Mr. B. F. Bush discovered a small tree growing abundantly in the swamp, and collected specimens of the trunks, branches with staminate catkins, and a few old leaves. Notwithstanding the incompleteness of the specimens, Mr. Bush shrewdly located the plant in *Leitneria*, a monotypic genus heretofore known with certainty only from Florida; and a comparison with specimens of *L. Floridana* in the Garden herbarium, collected many years ago in Florida by Dr. Chapman and Dr. D. V. Dean, showed the correctness of the generic determination, though certain differences in minor points were noticeable. In April, 1893, he again visited the locality and collected other material in leaf and with half grown fruit; and shortly afterward Mr. Henry Eggert gathered it with nearly mature fruit.

So far as we now know, the tree occurs in the deep swamps of Butler and Dunklin counties, where it is associated with plants of distinctly southern range, such as *Taxodium distichum*, *Acer rubrum Drummondii*, *Nyssa uniflora*, *Planera aquatica*, and *Polygonum densiflorum*. As I have convinced myself by personal observation at Kennett and Neelyville, it grows in rich swamp soil in sloughs and similar places, which never become dry and where there is usually from six inches to two or three feet of water; and Mr. Bush states that along the St. Francis River it is most frequent in water from three to five feet deep, where it is rooted in the basal mass of *Polygonum densiflorum*, the common swamp smartweed of that region, which occurs in dense growths often forming a floating

LEITNERIA FLORIDANA, IN THE BOG.

accumulation on which in places a man may walk. Certain of these sloughs are almost exclusively occupied by the *Leitneria*, which has a spreading root system confined to the surface layers of the soil. Apparently suckers arise from some of the roots, as is the case with the Ailanthus and White Poplar, but I have not been able to actually trace these young shoots to the older plants, though their root system is usually developed out of proportion to their size.* The impression made on one by such a Leitneria swamp is that of a tangle of coarse bushes from five to ten feet in height, but on closer observation it is evident that each stem rises separately from the soil or water, so that the plant lacks the clustered bushy habit which distinguishes a shrub from a small tree, and it not infrequently attains a height of fifteen to twenty feet and forms a trunk from three to five inches thick toward the base, where it gradually increases in thickness as do many other swamp trees.

Such arborescent specimens have a clear cut trunk below and are loosely branched above, with the ascending ultimate twigs commonly as thick as a lead pencil. Its bark is gray below and rather smooth, usually mossgrown where wet. The twigs incline to brown, or in the case of suckers are almost orange colored, and are marked by numerous slightly prominent lenticels usually of a lighter gray. During the first year they are densely pubescent with ascending dingy hairs, some of which persist during the second year, but ultimately they become glabrous. The leaf scars are five-ranked, rather uniformly distributed along the twig, slightly elevated, and of a general crescent form with obtuse angles and a not infrequent trilobation. Each contains three relatively large bundle scars. No stipule scars are to be seen.

The small persistent terminal bud is broadly conical and

* Apparently connected with this mode of spreading, is the preponderance of one sex in each swamp; a fact which Dr. Dean also informs me he has observed in Florida.

protected by about a dozen obtusely triangular gray-tomentose scales, which evidently represent undeveloped leaves and some of which usually persist for a year or two at the annual nodes, ultimately leaving rings of narrow transverse scars marking the site of former winter buds. On mature plants the upper axillary buds are generally flower buds, and develop in the autumn into oblong erect subsessile hairy catkins about half an inch long, surrounded at base by the bud scales, which pass into the very acute scales of the inflorescence. The trees are dioecious, and while the catkin character of the flower shoots is very evident on the staminate trees, it is much less noticeable on pistillate trees, the catkins of which are not above half the thickness of the others, and with correspondingly narrower scales. The lateral leaf buds are half ovoid, small, appressed to the stem, and protected by a few scales similar to those of the terminal bud. So far as has been observed, no supernumerary buds, either collateral or superposed, occur.

The leaves are lanceolate to elliptical lanceolate, acute at each end, entire, very narrowly revolute, 3 to 4 inches long, on half-round petioles about 1 in. long, and densely appressed villous, with a few interspersed clavate glandular hairs, especially on the petiole, and evident only on close inspection. With age they may become as much as 3×7 in. with petioles 2 to 3 in. long, and are then glabrate and somewhat glossy above except along the midrib and principal veins, thick and of coriaceous texture, and finally very rugose on the paler under surface from the prominence of even the finer veins. Stipules have not been seen.*

The flowers expand before the leaves, early in March, when *Acer rubrum Drummondii* is in bloom. The stam-

* In *Leitneria Floridana* stipules are said to occur by Baillon, Hist. des Plantes, vi. 241; Van Tieghem & Lecomte, Bull. Soc. Bot. de France, xxxiii. 184; and Heim, Recherches sur les Diptérocarpacées, — Thesis, Paris, 1892, — 176. They are not found by Chapman, Fl. So. U. S. 428; Oliver, Hooker's Icones Plant. ser. 3, i. pl. 1044; and Bentham & Hooker, Genera Plantarum, iii. 397.

inate catkins then become from one to two inches long, generally curved outwards, and their scales spread just enough to expose the stamens and allow the very abundant and powdery yellow pollen to escape. The soft parenchyma of the axis of inflorescence becomes torn in various directions as the catkins elongate, so that when they have reached their full development it is loosely fissured throughout. The fibrovascular bundles at the same time are poorly developed and almost unlignified, so that it is almost impossible to dissect a catkin without tearing it in pieces. The same loose texture exists in the basal part of the catkin scales, where they have increased in length during anthesis, and as the outer part is considerably longer than the inner, it assumes a series of characteristic transverse wrinkles below. This separation of the tissues in both axis and bract, gives rise to the curious appearance in longitudinal section which is shown in plate 32, fig. 4–5, for the cleft in each bract is decurrent down the axis to the point where the firmer fibrovascular bundles emerge for the next flower. The staminate flowers, so far as I have examined them, are glabrous and quite destitute of a perianth or involucre of any description, and consist simply of a whorl of about ten short filaments a little dilated at base and surmounted by slightly versatile but nearly erect extrorse two-celled anthers dehiscing longitudinally. The pollen grains are nearly globose, smooth, slightly 3 to 4-grooved with underlying thickening of the intine, and fall from the dehiscent anther very readily, and there is no doubt that the species is wind pollinated.*

The pistillate catkins possess the same loose lacunose structure as the staminate, though the axis is far less torn. When fully developed they are rarely over half an inch long, and it requires some little care to detect their presence on

* The structure of the staminate flowers, aside from the lacunose character of the axis and bract, and the extrorse facing of the anthers, is well shown by Baillon, *l. c.* 240, f. 214; Oliver, *l. c.* f. 1 to 3; and Heim, *l. c.* pl. 10, f. 1 to 6. Baillon, *l. c.* 239, mentions bractlets as being sometimes present.

the trees, whereas the staminate catkins are very evident from a considerable distance. Unlike the staminate flowers, the pistillate, which are limited to the upper axils, are very short-stalked or with a rudimentary disk, and possess a rudimentary involucre or perianth of a few small, glandular-fringed scales, the largest two of which stand nearly laterally while the remainder are dispersed along the side next the axis of the catkin.* Only one carpel is present. The ovary is shortly ovoid, finely pubescent, one-celled, and contains a single ascending parietal ovule with the micropyle directed upwards. The green or slightly reddish style is attached a little at one side and in anthesis curves outwards and becomes grooved on the stigmatic side, or somewhat flattened, with the stigmatic surface undulated, possessing the general characters of wind-pollinated stigmas. The placenta and stigmatic groove are turned away from the axis and face the bract, a very unusual position for the suture in a monocarpellary flower, and one which appears to indicate that the flower is in reality reduced from a former state in which there were two carpels radially arranged with reference to the bract, or perhaps a larger number; and this inference that the simple flower of *Leitnera* has been formed by the reduction of an originally more complex flower is further supported by the presence of a rudimentary perianth about the pistil, and by the reported occurrence of abortive pistils near the end of the staminate catkins in some instances,† and of one or more stamens within the scales of occasional pistillate flowers.‡

The fruit is an erect compressed dry drupe measuring

* Eichler (Blüthendiagramme, ii. 42) calls attention to the large size of the lateral scales, which, from analogy with *Myrica,* he regards as bractlets, considering the others as a perigone, and Van Tighem & Lecomte (*l. c.* 184) recognize a calyx as present in the pistillate flower. Heim (Ass. Franç. *l. c.* 231) on the other hand speaks of the absence of both calyx and corolla, in agreement with Baillon, who speaks of the whorl of scales as a false calyx (*l. c.* 240, note).

† Oliver, Hooker's Icones, *l. c.* p. 34.

‡ Baillon, Hist. vi. 240, note.

about 6×8×22 mm. in the Floridan specimens, though in the few Missouri specimens that I have seen it was of scarcely more than half this size. Its surface is coarsely rugose-reticulated over the firm fibrovascular bundles of the pericarp. Near the top it is marked by an oblique scar left by the caducous style, and it contains a single large seed with a straight embryo and a rather thin layer of albumen.*

So far as can be made out at present, the Missouri *Leitneria* differs from that of Florida only in its larger size,— the southern plant being described as a shrub 2 to 6 feet high,— in its somewhat larger more coriaceous leaves rarely more than acute at apex, while those of the Floridan plant are usually somewhat acuminate, and in its apparently smaller fruit. Neither of these characters, however, need of necessity be of specific value, nor represent more than individual variation due to habitat, climate, or age.

In an account accompanying his illustrations of *Leitneria Floridana*, Professor Oliver † mentions " specimens of perhaps a second species of *Leitneria* from Texas, collected by Drummond; " and Bentham and Hooker ‡ and Hemsley § admit this probable second species. In reply to an inquiry, Professor Oliver writes me that the material of this form consists of imperfect specimens without original label but labeled by Sir William Hooker as from " Rio Brazos, Texas, Drummond; " and he adds that so far as these specimens go, he does not now see any reason why they should not belong to *L. Floridana*, though the catkins are

* Except for the extrorse placental suture, and the lacunose bracts and axis, the structure of the pistillate flowers is well shown by Baillon, f. 215; Heim, pl. 10, f. 7 to 10; and Oliver, f. 6 to 8 — where the position of the stigmatic groove is correctly shown, but the placenta inverted. The fruit and seed characters are also shown by Baillon, f. 216; Heim, pl. 10, f. 11 to 22; and Oliver, f. 9.

† Hooker's Icones Plantarum, 3 ser. i. p. 34.

‡ Genera Plant. iii. 397.

§ Biol. Centr. Amer., Bot. iii. 162, iv. 193.

perhaps slenderer. In a letter accompanying this note, Mr. Hemsley states that he also suspects that all of the *Leitneria* material is of one species.

Dr. Chapman informs me that in Florida the original stations of the species on the coast have long since been washed away, but he afterwards found it inland, where, nevertheless, its distribution is not known to be more than very restricted. Whether the Texan material referred to above was actually gathered along the Brazos, or possibly further east, where Drummond also collected extensively, the occurrence of *Leitneria* in Missouri is, therefore, very remarkable. But the investigations of Mr. Bush have shown that this part of our State is a meeting-point for the floras of the Middle States, the eastern Gulf region and Texas.*

The reason for the extension of the Gulf Flora noted, appears to lie in the deep swampy character of much of the land along the general course of the Mississippi River in southern Missouri and northern Arkansas as well as further toward the Gulf. This entire region is noted for the present fluctuations in its water level, due to artificial elevation of the immediate bounds of the great river and its tributaries, some of which nevertheless are destroyed almost every year during freshets; but presumable natural changes, and the large measure of success which has been reached in confining the streams to their channels and inducing a more rapid flow near the mouth of the Mississippi, have resulted in lowering the maximum average level of the water in case of inundation, and a far more perfect drainage of the lowlands than formerly, during the season of low water. This seems to be indicated quite clearly by a study of the cypress trees of the region. I believe it is generally admitted that the level to which the root knees of the cypress rise in wet cypress swamps corresponds closely with the normal flood water level. This is

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* Fifth Garden Report, 140.

the case in the deep sloughs of the Varner and St. Francis rivers near Kennett, though at low water the knees emerge about two feet. But here and there dead knees, quite unconnected with standing trunks, or clearly belonging to the shells of old trees none of which are now living, rise some three feet beyond the level marked by the knees of existing trees. These vestiges of an earlier forest growth appear to indicate that when they were in their prime the water level stood several feet above the present flood level, and so far as can be estimated from the trees this was somewhere from two hundred to five hundred years ago.

Professor R. Ellsworth Call, who has made a geological study of the region in which these plants now appear to find their northernmost home, writes me that the Mississippi river formerly without question flowed far to the west of its course to-day, and in comparatively recent geologic times cut away the opposing ridge below Cape Girardeau, and excavated its present channel and the lowlands around. Meantime it has swung across the valley several times, but its westward movement has been successfully resisted by the remains of the great Tertiary plateau or northward deposit of the ancient Gulf, which extends from Florida to Mexico and northwards to this region, of which Crowley's Ridge is believed to be the last remaining vestige in the middle valley. He mentions as interesting in connection with these changes in the Mississippi and its immediate valley, the fact that the Ohio long preserved its integrity to a point not far from the present site of Helena. He also states that there can be no question that these changes at times have been retarded by depression of the whole area, and at times hastened by elevation; that there have been comparatively recent times when all the region about northeast Arkansas and southeast Missouri was a veritable marshy waste; and that this condition has been several times repeated, with a synchronous ameliora-

tion of climate favoring the northward extension of a subtropical flora over the region.*

It seems probable, therefore, that *Leitneria* and the species of the Floridan flora which accompany it in the Missouri swamps, represent the remnants of a warm temperate swamp flora which at one time extended continuously in the low lands, around the coast and up the river, from Florida to the upper limits of the present deep swamps; and that they are now likely to be found in such situations at any point between the extremes, where the original conditions have remained little or not at all changed by the general drainage which has been progressing at least for the last few centuries. One of the most promising fields for botanical exploration in the eastern United States, and one of the least known, is the swamp region of the lower Mississippi Valley and the Gulf Coast; and I have little doubt that a fuller knowledge of the flora of this region will not only confirm the explanation here offered of the occurence of *Leitneria* in Missouri, but extend its known range from this point to its original locality in Florida. Unless there is an error in the label of Drummond's specimen, it should also be found in similar situations across Louisiana and around the Gulf in Texas.

Mr. Bush's attention was first called to the occurrence of *Leitneria* in Missouri by the frequent mention in the swamps of a very light "cork wood," greatly surpassing even young tupelo (*Nyssa*) in buoyancy, and much used by fishermen for floats on their nets; and the trunks which he placed in my hands were of such surprising lightness that I requested my friend Professor Nipher to determine the specific gravity of the decorticated wood. An exam-

* The results of Professor Call's work, here briefly outlined from his letter, are to be found in the Proceedings of the Iowa Academy of Science, 1887–9, 52, 85, and more fully, as volume ii. for 1889 of the Reports on the Arkansas Geological Survey. See, further, a paper by him in Amer. Journ. Sci. and Arts, 1891, xlii. 394, on the fossil woods of this region, also considered in his larger report.

ination by his assistant, Mr. Brogan, shows it to possess a density of 0.207, water being taken as unity.* As is often the case with the roots of light trees, those of this species are appreciably lighter than the stem, and a similar determination made by Mr. Timmerman at the request of Professor Nipher, gives for its root wood a density of 0.151, though as a cylinder of 3.79 cc. only could be used, it is probable that this determination is less accurate than that for the trunk.

In his treatise on the forest trees of the United States,† Professor Sargent gives a tabulation of the specific gravity of the woods of all the North American trees recognized at that time, as determined at the Watertown Arsenal. From his tables it appears that the lightest known native wood (that of *Ficus aurea* of Florida), has a density of 0.2616, and the heaviest (also a Floridan species, *Condalia ferrea*), has a specific gravity of 1.302, while the density of the great majority of species lies between 0.400 and 0.800.‡

From a set of tables based on the experiments of Captain Fowke,§ on the woods exhibited at the Paris Exposition of 1855, and the London Exposition of 1867, it appears that an East Indian wood, "Dedoaf Tha," has a specific gravity of 0.260, very nearly that of *Ficus aurea*

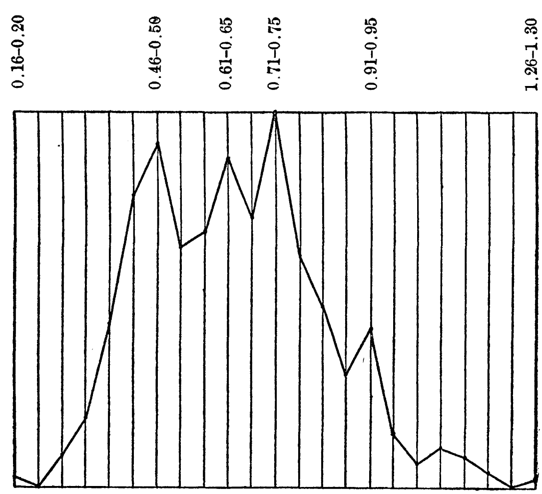
* Professor Nipher informs me that in the determination, a cylinder was used, turned as accurately as possible, which was measured at a sufficient number of points to give average values, and the density was obtained by calculation from the dry weight of the cylinder, correction being made for absorption of water between the time of removal from the drying bath and the completion of the weighing, it having been found that the gain from the atmosphere was .007 gr. per minute, for the cylinder used.

† Final Rept. Tenth Census, ix. 249.

‡ As a few examples may be mentioned the common hickories, ranging from 0.810 to 0.837, white oak, 0.747, tupelo, 0.519, the willows and poplars, usually considered very light woods, and lying between 0.363 and 0.607, and white cedar, a favorite material for light boat construction, with a density of 0.332.

§ Science and Art Department of the Committee of Council on Education, London, printed by George E. Eyre and William Spottiswoode, 1867, p. 10.

as given in the census tables. *Ochroma lagopus*, one of a number of so-called cork woods enumerated by Wiesner,* is said to have a density of 0.250,† but I cannot place my hand on any determinations lower than this. Professor Nipher tells me that the specific gravity of common cork (the bark of *Quercus Suber*) is given by Ganot as 0.240. Although individual variability and the difficulties of determining the specific gravity of porous and absorbent bodies like wood make it unwise to accept any of these figures as invariable, it appears from them that the wood of *Leitneria* is very markedly lighter than the bark of the cork oak, which itself is considerably lighter than any other wood of which a record can be found.



FREQUENCY OF TIMBER DENSITIES.

The appended curve, compiled from the census tables, shows the relative frequency of occurrence of the different degrees of density in our native timbers, each co-ordinate representing a difference of .050, and each species falling within this range being represented by a vertical distance of

* Rohstoffe, 578.

† Goodale, Physiological Botany, 145.

1 mm. on the co-ordinate. Thus, one species has a specific gravity between 0.16 and 0.20 inclusive; none occur between 0.21 and 0.25; 46 are found between 0.46 and 0.50; and 50 lie between 0.71 and 0.75. The majority of species (242) occur between the maximal points of 0.46 and 0.75, and it is evident that the fall is much more abrupt from these common densities to the lowest recorded density than to the highest, so that any extension in this direction is more remarkable than a corresponding one in the other.

As the density of wood freed from resin etc., air and water, is about one-half greater than that of water, the reason for the extreme lightness of the wood of *Leitneria* is to be looked for in connection with its loose structure, the softness of its tissues, which are easily compressible under the thumb nail, and the absence, at least in the largest specimens I have seen, of any heart wood, the texture being homogeneous throughout.* It was, therefore, subjected to a rather careful microscopical examination, with the following results.†

The pith is nearly round in cross section, although where the bundles of the primary wood join it they project slightly, giving it a minutely crenulate outline. It is continuous and of uniform texture, thus differing from the pith of plants like *Paulownia* and *Lonicera* which are excavated, or *Juglans*, which is chambered,‡ and from that of *Liriodendron*, etc., which, though solid, is traversed by firmer transverse plates. The cells, as is usual in pith, are approximately isodiametric and polygonal, as seen in cross section, a little smaller near the periphery; and in longi-

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* On this general subject see Nördlinger, Gewerblichen Eigenschaften der Hölzer, Stuttgart, 1890, 17; and Techn. Eigenschaften der Hölzer, Stuttgart, 1860, 115.

† The substance of this paper was presented orally before the Academy of Science of St. Louis on May first, 1893, and illustrated by specimens of the plant and photomicrographs, some of which are here reproduced in half tone or are made the basis of line engravings, showing the structure of the wood and bark.

‡ The "discoid pith" of Morren, in Ann. of Nat. Hist. 1839, iv. 73.

tudinal section they often appear as rectangles, with their greatest diameter transverse. Their walls, which are very thin, show, nevertheless, a decided secondary thickening, and are marked by simple pits, as is usual in pith of this description. Toward the wood, and especially where the pith rays pass outward to the branches, occasional cells in more or less marked vertical rows occur, with large stellate crystals.

At the margin of the pith a number of layers of cells of reduced diameter but several times as long as the pith cells, constitute a pith sheath, and gradually merge into what are virtually wood parenchyma cells. They have the same simple pits as the pith cells, but are arranged in vertical rows in relation with the elements of the xylem, and vary in length from twice to four or five times their diameter. In the mass of parenchyma so formed at the margin of the pith, are found intercellular secretion reservoirs, each of which is surrounded by a layer of oblong secreting cells with walls not appreciably thinner than those of the parenchyma immediately about them. From one to two dozen such passages are to be seen in a cross section of the stem.* Though as a rule they occur singly, it is not uncommon for two of equal size to stand close together, separated by only a few layers of cells, or for small ones to stand on one or both sides of a larger one. The secreting cells are usually

* These were formerly attributed by Van Tieghem (Ann. des Sci. Nat. 7 ser. i. 64, and Van Tieghem and Lecomte, Bull. Soc. Bot. de France, 1886, xxxiii. 182) to the apexes of the primary xylem wedges, but, accepting as the inner limit of the wood, the position of the innermost vessels, Professor Van Tieghem now recognizes these secretion passages as pertaining to the pith (Morot's Journal de Botanique, v. 384, 385), thus coming into agreement with Müller (Engler's Bot. Jahrbücher, ii. 449), Burck (Ann. Jard. Bot. Buitenzorg, vi. 151), and Heim (Ass. Franç. p. l'Avanc. des Sciences, 1891, i. 231; Rech. s. les Diptérocarpacées, Thesis, 1892, 175), who have attributed the similarly situated passages of Dipterocarpeae to the pith. But Reinsch, Engler's Jahrb. xi. 374, speaking of the Balsamifluae, again calls attention to their close connection with the xylem, and, indeed, it appears extremely difficult so to define the hadrom bundle as unequivocally to separate it from the adjacent pith.

quite convex on the free side, and sometimes protrude into the passage as papillae or in balloon-like outgrowths. Their secretion is a yellowish resin, which fills the passages in sections cut dry and examined in water, but rapidly dissolves when this is replaced by alcohol drawn in at one side of the cover glass, leaving a residue of fine emulsion drops similar to those formed when an imperfectly anhydrated preparation is mounted in Canada balsam. In sections examined in water after being cut dry, the contents of the secretion passages are traversed by fractures, sometimes regularly curved, and their high refractive power gives rise to the appearance of a limiting membrane about the individual masses, suggestive of a raised cuticule of the secreting cells, beneath which, according to Tschirch,* the formation of the resins of schizogene passages occurs. In observing the solution of the resin on the addition of alcohol, however, the apparent membranes are seen to completely disappear at once, and I have not been able to detect either cuticular blisters or vestiges of the bases of such blisters in these sections after the solution of the resin, nor in any of the numerous sections of alcoholic material which I have examined.†

Just outwards from the situation of this ring of secretion passages, each wedge of the hadrom or xylem begins with

* Berichte Deutsch. Bot. Ges. xi. 201, and Pringsheim's Jahrb. xxv. 375.

† Some difference of opinion exists as to the nature of the secretion within these passages. Van Tieghem and Lecomte (*l. c.* 182) speak of it as a resin, while Heim (Thesis, 176) calls it a balsam. The entire group of terpenes, ethereal oils, resins, and balsams, is a difficult one chemically, and I do not venture to pronounce on the one now in question further than to say that it is insoluble in water, soluble in cold alcohol except for the emulsion residue referred to above, and that Mr. Bay, who at my request tested it with the Unverdorben-Franchimont reaction to acetate of copper (Poulsen, Mikrochemie, 73; Zimmermann, Bot. Mikrotechnik, 89), found that it assumes with this reagent the green color characteristic of resins and terpenes. It may be noted that the same reagent gives an abundant brown precipitate throughout the bark, indicative of the presence of tannin. On the resins see further Tschirch, Pringsheim's Jahrb. xxv. 370.

a few tracheides and spiral vessels about 20 μ in diameter, surrounded by wood parenchyma. Aside from this, except where the bundles pass out to the leaves, no true spirals occur in the stem. The remainder of the xylem consists of pitted tracheides and ducts, wood parenchyma, and, chiefly, libriform cells. Except for the spiral vessels mentioned above, the vascular elements of the wood are all furnished with bordered pits, a scalariform reticulation marking their contact with the medullary rays.

The pitted vessels are distributed through the stem in a characteristic way, as is usual in woody plants. Each year's growth in the secondary wood begins with a greatly interrupted row of vessels large for the plant, and measuring from 50 to 95 μ in diameter. In addition to these vernal ducts, each year's zone of wood contains a number of groups of similar but smaller vessels, which are arranged either approximately parallel to the circumference or with an oblique direction outwards, often strongly accentuated in the older wood where it may become quite radial, and, as a common thing, grading in size from the middle to each extremity or from one end to the other, most diameter measurements lying between 25 and 35 μ. These groups consist of the elements usual in such duct accumulations, namely vessels, tracheides, and wood parenchyma. The vessels show a complete disappearance of the cross septa which originally divided the vertical rows of rather short cells from which they arise, except for a narrow ring around the margin, in this respect differing very markedly from the similar vessels of *Liriodendron*, *Liquidambar*, etc., where the perforations are formed in such a way as to leave the original septum as a persistent scalariform plate running obliquely across the mature duct.

The wood parenchyma, which is not abundant, and stands in close connection with the ducts and annual rings, does not differ particularly from the parenchyma already described about the secretion passages in the pith sheath. The tracheides as a rule are similar to the libriform or common wood

cells, presently to be described, except that their walls are somewhat thicker,—sometimes much thicker,—and marked, even on the tangential sides, with bordered pits very different from the simple pits of the libriform cells and parenchyma. Their walls not infrequently show a spiral striation which in its most marked form consists in a fine acute spiral ridging of the inner surface of the cell, the ridges, however, differing from those of the spiral vessels in being wedge shaped with a broad base, whereas in the vessels they are of a generally round section, and attached by a narrow base, which is easily broken, so that they can be uncoiled from within the lumen.

Except for these masses of vessels with their accompaniment, and a layer of cells presently to be described, at the limits of each year's growth, the wood consists of libriform or ordinary wood cells, which differ from the tracheides in possessing on the radial walls very small, obliquely crossing, not evidently bordered pits, scattered or irregularly grouped. They are fusiform or, more accurately, obliquely truncated at the ends, which overlap in such a way as to be very evident in tangential sections while much less obvious in radial sections. Their length is usually fifteen to twenty times their diameter, the measurements as a rule lying between 15×275 and $20 \times 375\,\mu$. Now and then these libriform cells are found with transverse partitions running directly across, one or two to each cell, a condition that has been observed frequently in other woods. While striation is much less evident than in some of the tracheides, it is sometimes to be seen.

Rings indicative of the annual (or more accurately periodic) growth in thickness of the stem, though nearly invisible to the naked eye, are evident on an examination of the wood under a lens, being partly caused by the occurrence of a broken row of vernal ducts, and in part by a gradual reduction in the radial diameter of a few rows of libriform cells formed toward the end of the growing season, whereas those first formed the next spring are of

ample size. The most striking feature of these annual rings, however, consists in the production of a row of parenchyma cells replacing the libriform as the first series cut off by the cambium each spring at the beginning of the year's growth. These cells are about ten times as long as broad, with horizontal septa, some of which are evident in all cross and radial sections of the wood, and, like other cells of the wood parenchyma, they show simple pits similar to those of the medullary rays. Exceptionally this annual layer of parenchyma is locally doubled by tangential division.

Between the xylem wedges occur the usual medullary rays. So far as I have seen, these rays, except where they stand in connection with pith rays, are not more than two cells in thickness, and it is extremely unusual to discover more than a single row of cells in their cross or tangential section. As seen in longitudinal section, they consist of from one to about twenty vertical series of cells, most commonly about ten. These cells usually measure 18 to 25 μ in height, 7 to 10 μ in width, and 40 to 75 μ (as a general thing) to above 100 μ in radial length. Their vertical septa frequently are somewhat oblique when viewed in either transverse or radial section. Their walls are thin, and simply pitted to correspond with abutting cells.

All of the elements of the xylem show the customary middle lamella, with a secondary thickening, which, however, is very slight, so that the walls of the libriform cells are rarely over 1.5 μ thick, while the medullary ray cells are thinner, and the tracheides and the wood parenchyma cells generally range respectively a little thicker and a little thinner than the libriform, the vessels being, in fact, the only thick walled cells of the wood, except for occasional groups of exceptionally thickened tracheides.

From its gross anatomical characters, the wood of *Leitneria* would be compared with Hartig's group of dicotyledonous woods having all of the ducts small, those of the

spring growth neither large nor numerous, and the medullary rays invisible to the naked eye.* The occurrence of a single broken row of vernal ducts somewhat larger than those of the rest of the year's growth, the oblique position of the groups of the latter, and the absence of loose parenchymatous bands, suggest a comparison with *Aster argophyllus*, certain species of *Ulmus* and *Celtis*, and, particularly, *Daphne Mezereum*.† Except for the absence of coarse parenchyma bands, it also resembles somewhat the wood of *Ailanthus*, *Hippophae*, and numerous Leguminosae, though in these the vernal ducts are usually larger and more numerous, and the secondary thickening of the medullary rays and the libriform cells is far more marked.

The cortex of *Leitneria*, which, as has been stated above, is rich in tannin, is rather thin, and consists at first of fundamental parenchyma, which is collenchymatously thickened, with large often transversely elliptical pits, for about eight layers of cells immediately below the epidermis, and passes into a like number of thin walled cells by a transition through about three layers, while between this primary cortex and the cambium an abundant secondary cortex is developed, containing large fan-shaped abundantly crystalliferous dilatations of the principal medullary rays, between which lie broad wedges of bast. Except for a few small and scattered bundles of hard bast fibers in the pericycle, at the inner border of the primary cortex close beneath the collenchyma, none of the bast fibers become thick walled, but they remain as long wide generally irregularly collapsed tubes with oblique often clustered simple pits, and destitute of protoplasm. Traversing these bast wedges are a few secondary rays, while tangentially they are parted by plates of thin walled parenchyma cells from two to about five times as long as broad, with horizontal septa, a few rows of which contain crystals; and among these cells, rich in

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* Hartig, Timbers and How to Know Them, 8.

† From an examination of Nördlinger's set of 1100 cross-sections of woods.—Cf. p. 78 of text accompanying century xi.

protoplasm, sieve tubes should be found.* The two systems thus map out the bundles, in cross-section, into a series of quadrangles.

Throughout, like the wood, the cortex is destitute of secretion passages. The cork, which is formed immediately next the epidermis † during the first summer, cuts off a bark which does not become very thick, and is interruptedly stratified by the intercalation of masses of condensed cells between layers of more open cells.‡ Grit cells are entirely absent, and I have not satisfied myself that the primary cortical parenchyma is added to below the cork by the formation of phelloderm from the inner limits of the latter.

In sections just below the nodes, fibro-vascular bundles may be found running obliquely upwards through the cortex, from the xylem to the leaf scars.§ The tracheary elements of these bundles are spirally marked as in the primary xylem next the pith, and they are unaccompanied by secretion passages. So far as I have observed, their transit through the cortex is effected in a vertical distance little greater than the thickness of the latter, so that they

* Van Tieghem and Lecomte (*l. c.* 181) speak of these tangential bands as consisting of "tubes criblés," and it is clearly in them that the sieve tissue should be found; but notwithstanding repeated examination of sections from fresh, dry and alcoholic material, which had been subjected to treatment which renders the sieve tubes of *Tilia, Magnolia, Ulmus* and other trees very evident, I have quite failed to demonstrate sieve plates in the cortex of this species.

† So far as can be judged from specimens still retaining the epidermis, but with fifteen or twenty layers of cork cells, the first subepidermal layer of cortical cells becomes active as phellogen; but as this is formed in the early summer of the first year, while I have been able to study only very young shoots and those which had ended the season's growth, I have been unable to get a preparation showing the first segmentation, which would afford conclusive information on this point.

‡ This is to be compared with the annual cork layers described for Balsamifluae by Reinsch, Engler's Bot. Jahrb. xi. 367.

§ The occurrence of true cortical bundles in various groups of plants is discussed by DeBary, Vergl. Anat. 266; Mueller, Engler's Jahrb. ii. 449; Gilg, Ber. Deutsch. Bot. Ges. xi. 21; Burck, Ann. Jard. Bot. Buitenzorg, vi. 156; Heim, Thesis, 18, etc.

really belong to the pulvinus of the leaf, but this does not prevent them from appearing as distinct cortical bundles in favorably located sections (pl. 39 and 44 f. 1–3). Three of these foliar bundles, corresponding to the three bundle traces evident on the scars marking the former position of fallen leaves, pass into each petiole, where they soon unite to form a closed crescent-shaped ring of bundles. No isolated bundles are contained within this petiolar ring, the parenchyma within which includes a series of about twenty secretion passages similar in structure and contents to those of the stem, with which, however, they have no direct communication. From the petiole, a group of resin passages runs through the midrib of the leaf, a single one passing out into each of the finer veins. Stellate crystals are of rather frequent occurrence through the petiole and midrib, both of which contain collenchyma.

The upper epidermis of the leaf blade is smooth walled except for a few striated cells about the bases of some of the hairs, and consists of a layer of inconsiderably thickened cells, beneath which lies a layer of quadrate cells each of which contains a large stellate crystal. A layer of similar cells is also found between the veins and the lower epidermis, the cells of which are somewhat smaller and prominently wrinkled on the outer wall, so as to appear almost muricate in cross section. The stomata are not sunken below the general level of the epidermis. Tannin appears to be abundant in the epidermal layers.

Pubescence consists of two kinds of hairs:— abundant, slender pointed thick walled hairs, usually with several transverse septa, especially toward the often bulbously widened base, and mostly isolated, but occasionally binate; and less numerous clavate hairs, septate both longitudinally and transversely, their small cells with yellow contents. These compound hairs are chiefly seen on the young stem, the sides of the petiole, and the upper surface of the midrib of the leaf. The epidermal cells about the bases of the hairs are usually divided by a septum parallel to the leaf

surface. The mesophyll is composed of two or, mostly, three layers of compactly placed palisade cells only a little longer than broad, occupying the upper half of the leaf, and a spongy parenchyma with ample intercellular spaces below. No spicular cells have been observed.

The structure of the roots is interesting to this extent, that (at least in lateral roots, which, alone, have been examined) they are entirely destitute of secretion passages, which are thus seen to be confined to the pith sheath of the stem, the intra-fascicular parenchyma of the petiole, and the parenchyma of the veins of foliar organs, including the carpels. The elements of the root are essentially similar to those of the stem, and secondary growth in thickness is effected in the manner usual in the roots of Dicotyledons.

While I have found comparatively little starch in the stem of specimens gathered either in November or in the spring, the medullary rays and cortical parenchyma of the root contain an abundance of roundish grains, often binary, and of extremely variable size.

Dr. Chapman, who described the genus *Leitneria* and its single species, placed it among the Myricaceae because of its simple flowers arranged in spike-like catkins;* and in this he was followed by DeCandolle.† Subsequently Baillon examined it, and placed it with doubt in his group of Castaneae, beside *Myrica*, making it, however, the representative of a series which he named Leitnerieae,‡ and in which he also placed with question a Madagascar genus, *Didymeles*. This series was raised by Bentham and Hooker § to ordinal rank, under the name given by Baillon, and placed between the Platanaceae and Juglandaceae, with an indication of Urticaceous affinities, *Didymeles* being excluded. The order is maintained under the name Leitneriaceae by Engler,|| who places it between Myricaceae and Salicaceae.

* Flora So. U. S. 427.

† Prodromus, xvi. (2), 154.

‡ Hist. des Plantes, vi. 239, 258; Tison, in Baillon, Dict. de Bot. iii. 215.

§ Genera Plant. iii. 397.

|| Engler and Prantl, Pflanzenfamilien, iii. (1), 28.

In 1886, Van Tieghem and Lecomte,* after a histological study of the stem and leaf, decided, because of the stratification of the bast and the occurrence of secretion passages in the pith sheath and the leaf, that *Leitneria* may be placed in or at least joined to the polypetalous order Dipterocarpeae, its macroscopic characters being also not unlike those of that family except for its diclinous reduced flowers. More recently Heim † has reviewed its histological characters, and reached the conclusion that its affinities are rather with the group Balsamifluae or Liquidambareae of Hamamelideae (likewise a polypetalous group, with which Van Tieghem and Lecomte had also recognized that it might be compared in certain respects), near which for both anatomical and organographic reasons he would place the Leitnerieae, while allowing it to retain its autonomy.

Many botanists look on the Apetalae as only a provisional aggregate of orders with reduced inflorescence, which must be disrupted before a truly natural system of classification is reached; and efforts have been made from time to time to distribute all of these orders among the Polypetalae and Gamopetalae, just as single apelatous genera and species are universally placed in orders otherwise characterized by the possession of more complete flowers. This problem is one that may be expected to receive aid from the many comparative histological studies now being made, especially by French and German botanists, though no purely organographic system dispensing with the Apetalae has yet met with more than limited approval.

Against the approximation of the Leitnerieae to the Balsamifluae, may be urged the absence of secretion passages from the liber, and the non-scalariform duct perforations, though the floral structure suggests a possible further simplification of the type of this group. On the other hand, the absence of secretion passages from the root, the

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* Bull. Soc. Bot. de France, xxxiii. 184.

† C. Rend. Assoc. Franç. pour l'Av. des Sci., 1891, i. 231; Recherches sur les Diptérocarpacées, Thesis, Paris, 1892, 175.

narrow medullary rays, scanty wood parenchyma and hard bast, peculiar duct pattern, simple petiolar bundle arrangement, and the venation of the leaves, count against too close a union of the Leitnerieae with the Dipterocarpeae,— a conclusion which is further strengthened by the fact that no existing or fossil representatives of this order are known from the New World. For the present, therefore, the order Leitnerieae will probably be maintained either in the position it now occupies next the Platanaceae, or, in case of the dismemberment of the Apetalae, near the Dipterocarpeae or Balsamifluae among the Polypetalae; and on this point no one class of histological characters appears to be conclusive.*

The peculiar lightness and softness of the Missouri cork wood, combined with its slight porosity, suggest that it should find application in the arts if, as appears to be the case, it can be procured in suitable quantities for economical working, and while its small size bars it from very extended use, it is possible that it may prove a useful substitute for cork in the manufacture of bottle stoppers for chloroform and other gummy substances, which cause cork to tear badly after a little use.

* Attention should be called here to the close affinity which Agardh, Brongniart and Clarke have thought they saw between the Platanaceae and Balsamifluae.—On this point see Baillon, Adansonia, x. 134; Eichler, Blüthendiagramme, ii. 66, and, on anatomical grounds, Gris, Ann. Sci. Nat., ser. 5, xiv. 40, and Mémoire sur la Moelle, 267, and Reinsch, Engler's Jahrb. xi. 369. But Bentham and Hooker (Genera, iii. 396) do not at all agree with this conclusion.

EXPLANATION ON PLATES ILLUSTRATING LEITNERIA FLORIDANA.

The habit illustrations were drawn by Miss Grace E. Johnson, from living plants or herbarium material. The details are reproduced directly or redrawn from photomicrographs or drawings by the author.

Plate 30. — 1, Leafing twig, in spring; 2, autumnal leaf; 3, staminate catkin; 4, opening pistillate catkin; 5, branch with partly grown fruit. All natural size.

Plate 31. — 1, Pistillate, and 2, staminate shoots, in winter, natural size; 3, bud and leaf scar details, $\times 3$; 4, stem hair, $\times 150$; 5, exceptional, substellate arrangement of hairs, $\times 200$; 6, base of hair, $\times 250$; 7, glandular hair, $\times 180$; 8, nature print of young leaf, natural size; 9, lower surface of old leaf, $\times 2$.

Plate 32. — 1, Staminate flower, with portion of base of bract, and 2, dehiscent stamen, $\times 4$; 3, ventral, dorsal, and lateral view of indehiscent stamen, $\times 9$; 4, enlarged longitudinal section of a portion of a staminate catkin, showing fissuring of bracts; 5, part of a similar section, showing extrorse stamens and fissures of bracts and axis of inflorescence, $\times 18$; 6, pollen grain from one end, and in optical section, $\times 400$; 7, cross section of pistillate catkin, $\times 18$, showing fissured axis at *a*, adnate base of bract with fissure at *b*, receptacle or disk with perianth, glands, and subtending bract at *c*, ovary with ovule and subtending bract at *d*, lower part of stigma with bract at *e*, and upper part of stigma with bract at *f*, — the sections belonging to successively lower flowers, in the order of lettering, — from one of a series of celloidin sections, retaining the several flowers and their parts in their natural position.

Plate 33. — Details of pistillate flower and fruit: 1, fully expanded pistillate catkin, natural size; 2, young flower with bract and scales from the inner side, $\times 5$; 3, longitudinal section of young flower, showing disk and scales, $\times 18$; 4, scales or segments of perianth, $\times 18$; 5, longitudinal section of portion of catkin, $\times 18$, showing lacunose axis and bracts, and pistil at point of separation from disk; 6–7, ovule entire and in section, $\times 18$, — the bract at the left as in fig. 5; 8, fertilized ovary after fall of style, $\times 5$; 9–10, partly grown fruits, with longitudinal and cross sections, $\times 2$; 11, dried mature fruit, $\times 2$.

Plate 34. — Cross sections of wood of stem, showing duct patterns, $\times 60$.

Plate 35. — Similar sections, for the annual rings, the upper $\times 60$, the lower $\times 125$.

Plate 36. — Tangential sections of stem wood, the upper $\times 60$, the lower, showing septate libriform, $\times 125$.

Plate 37. — Tangential section of stem wood, above, showing dilated ray going to branch, ×125; and, below, partial radial section of stem, ×60, the xylem at the left, the phloem at the right,—showing complete duct perforations, stratification of liber, and serial arrangement of crystal cells in the latter.

Plate 38.— Cross section through wood and pith of stem, showing location of secretion passages, ×60; and radial section of pith, showing the greater transverse diameter of its cells, × 125.

Plate 39. — Cross section above, of outer part of wood and inner part of cortex, showing vernal row of ducts, quadrate liber, and, in the primary cortex, the small ducts of a foliar bundle; below, for comparison, a corresponding section of *Tilia Americana*, with quadrate bast wedges,— both ×60.

Plate 40. — Cross section of primary cortex of very young stem, showing epidermis and collenchyma; below, cross section of liber wedge, showing thin walled bast fibers with secondary rays and transverse parenchyma bands (the section torn through the cambium), — both ×125.

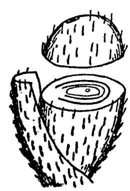
Plate 41. — Cross section of central portion of root, showing pith and xylem, — the large openings are ducts; below, longitudinal section of secretion passage in petiole, showing elongated form of secreting cells,— both ×60.

Plate 42. — 1, Enlarged radial section of stem xylem, showing medullary ray below, libriform cells at the right, striated transition to tracheides adjoining these, and striated tracheides with bordered pits at the upper left; 2, radial section, showing reticulated marking of medullary ray cells in contact with duct, ×400; 3, enlarged longitudinal section of duct, showing bordered pits and remnant of original transverse septum; 4, much enlarged cross section of wood, showing secondary thickening of libriform and medullary ray cells; 5, diagram of radial section of xylem crossed by medullary ray, ×200; 6, cross section, and 7, radial section of xylem, in diagram, ×200, showing parenchyma layer at annual ring,— the vernal wood at the right, the autumnal growth at the left; 8, diagram of tangential section of wood, showing libriform cells and medullary rays, ×200.

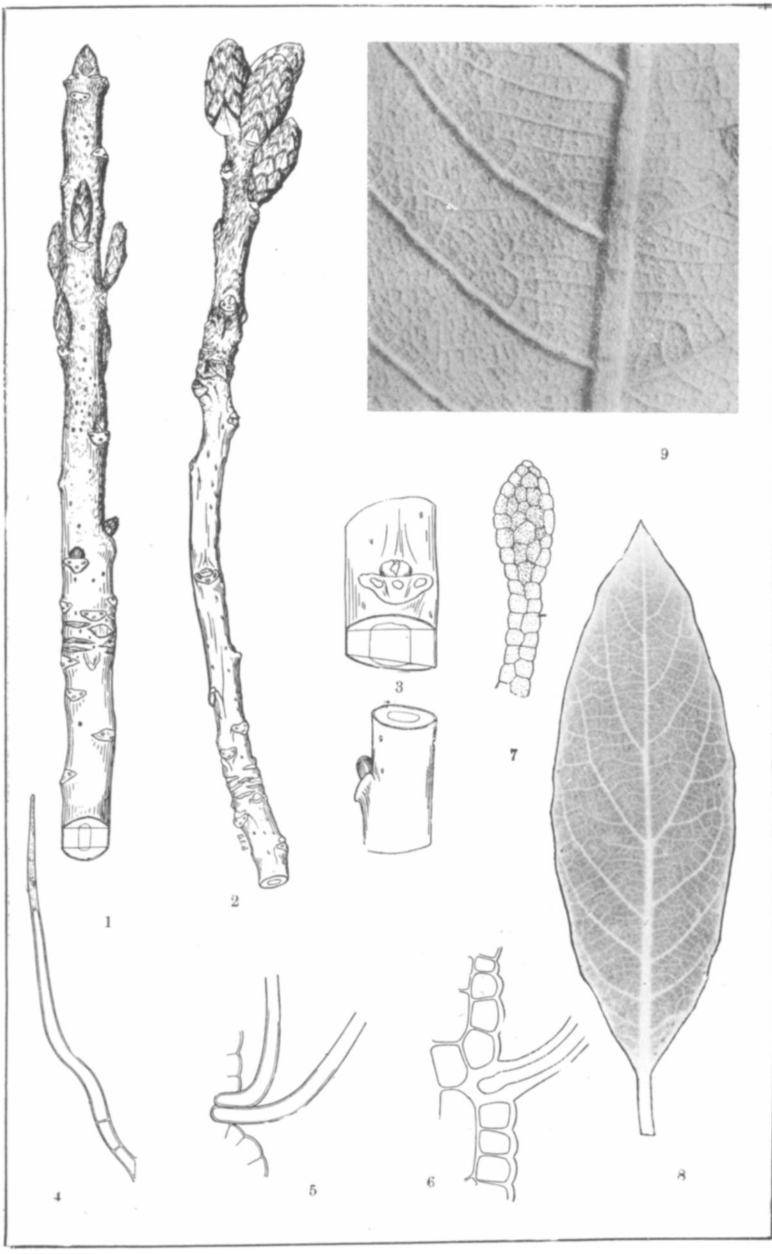
Plate 43. — 1, Radial section of xylem, showing libriform at the right, followed by tracheides, vessels, and wood parenchyma, the vessels subscalariform where adjoining a medullary ray, ×200; 2, cross section of secretion passage in pith sheath, ×320, pith at the left, xylem at the right; 3, radial section through the left hand portion of same, ×200, beginning with pith at the left, and ending with the secreting cells at the right; 4, cross section of outer part of pith (above) with stellate crystals, pith sheath, and innermost part of a xylem wedge, showing two spiral ducts, ×200; 5, radial section of outer cortex of old stem, showing stratified cork, ×200; 6, similar enlarged section of stem toward end of first season, showing phellogen layer and subjacent collenchyma; 7, tangential section of subepidermal collenchyma of young stem, ×200; 8, cross section, and 9, radial section of secondary bast, showing open bast fibers and interjacent bands of bast parenchyma, ×200.

Plate 44. — 1–3, Diagram of successively descending cross sections of young shoot at emergence of a branch, showing passage of the foliar bundles through the pulvinus and their union to form the petiole bundle, $\times 9$; 4, collenchyma of petiole, $\times 250$; 5, radial section of subjacent parenchyma, $\times 250$; 6, cross section of secretion passage of petiole, $\times 350$; 7, cross section of midrib and adjoining lamina of leaf, $\times 30$, showing two forms of pubescence; 8, cross section of very young shoot, showing collenchyma, epidermis, and base of hair, $\times 200$; 9, cross section of young leaf, and stoma, $\times 200$, showing crystal layer of upper epidermis, palisade and spongy parenchyma, and striated lower epidermis.

By accident, the position of the ovule in the upper figure of plate 33, f. 8 is shown inverted, the true position being that indicated in the corrected figure here given.



LEITNERIA FLORIDANA.



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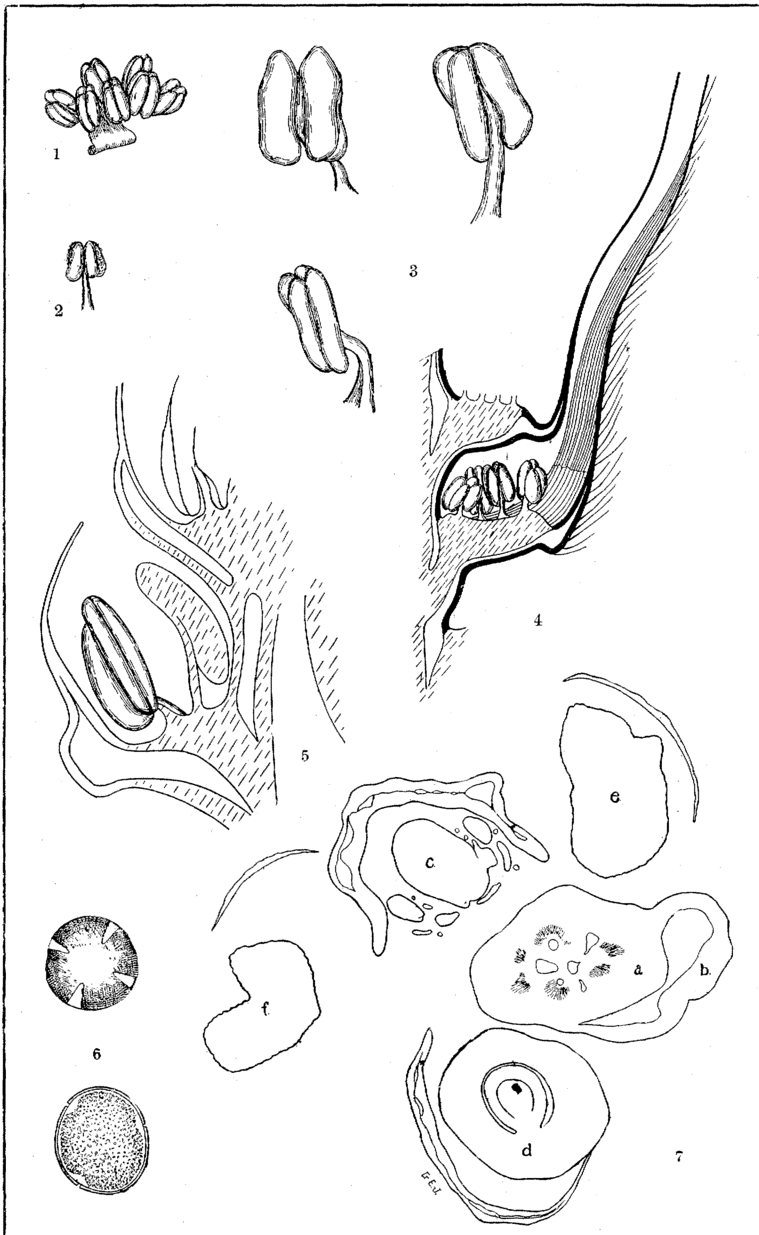

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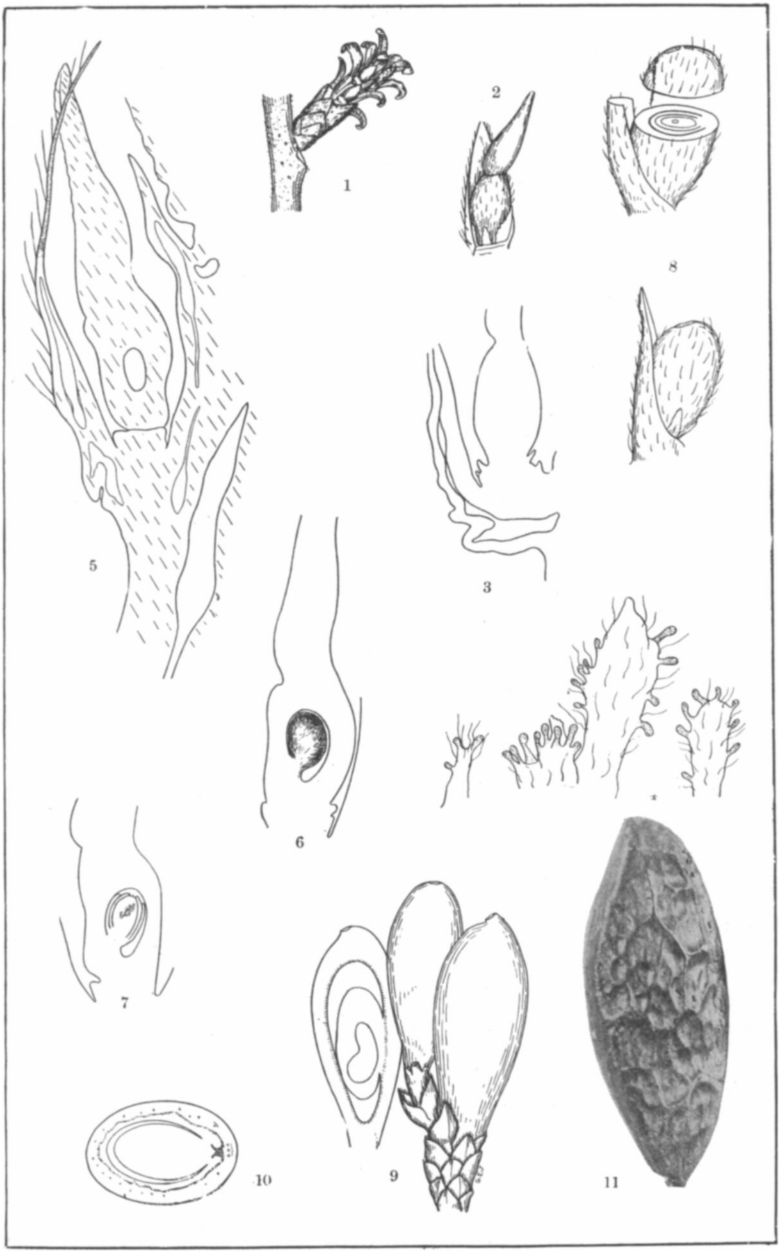

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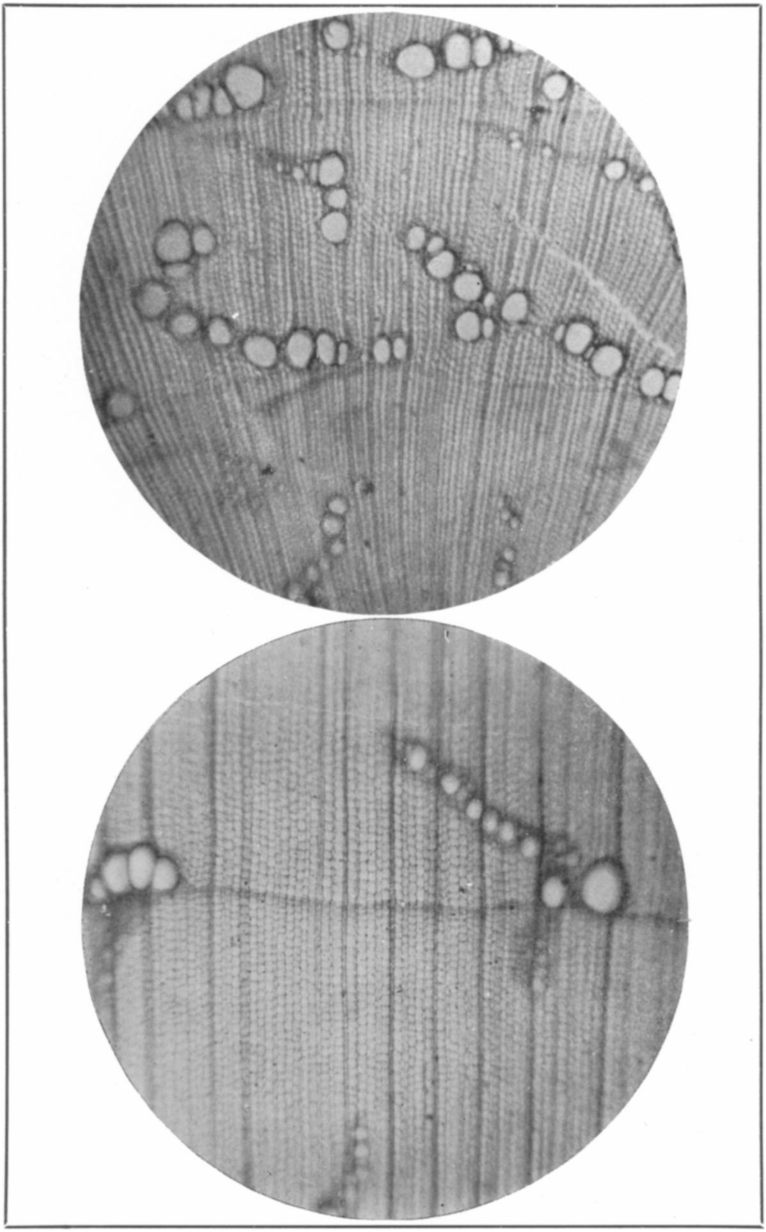

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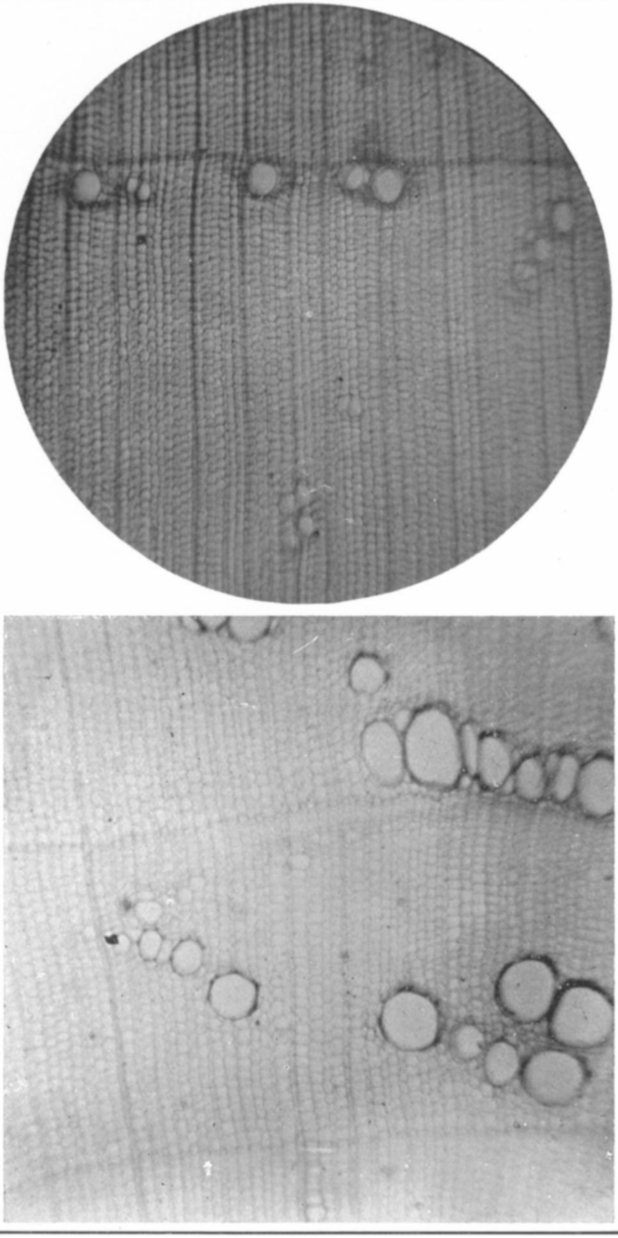

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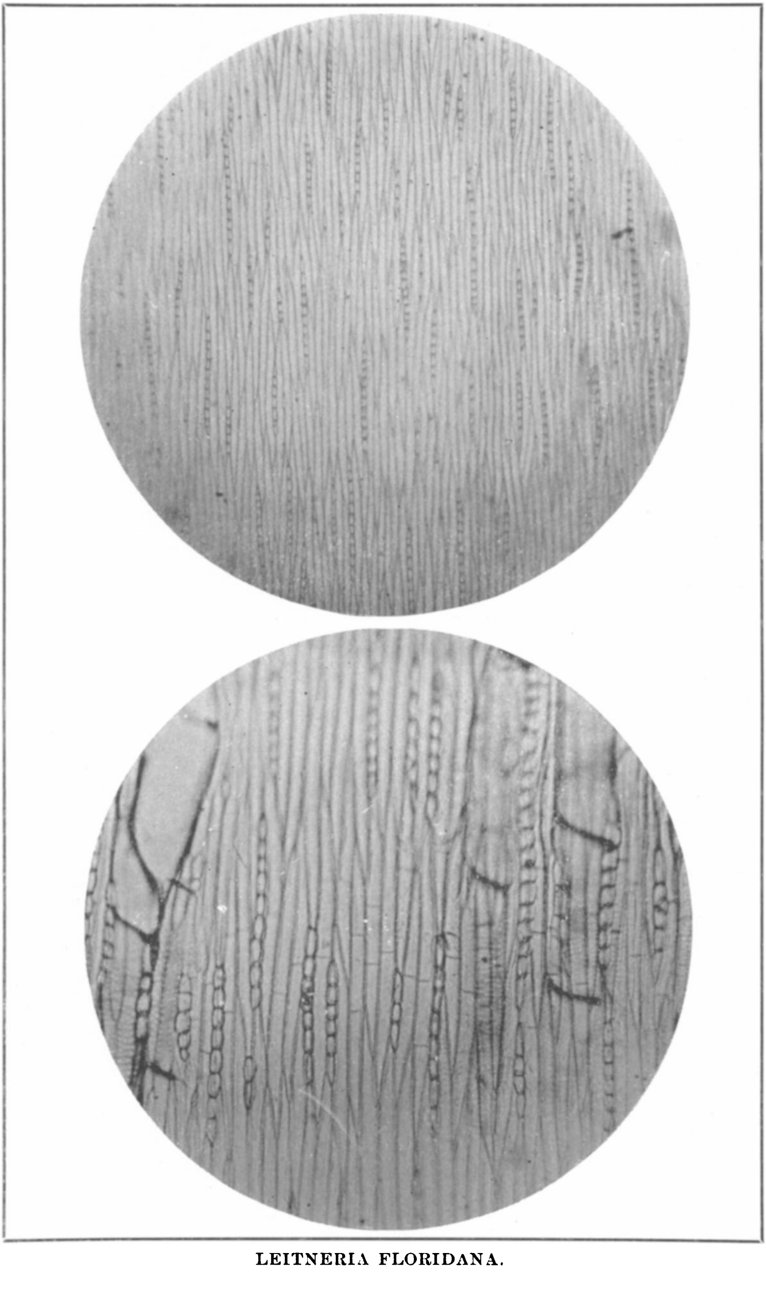

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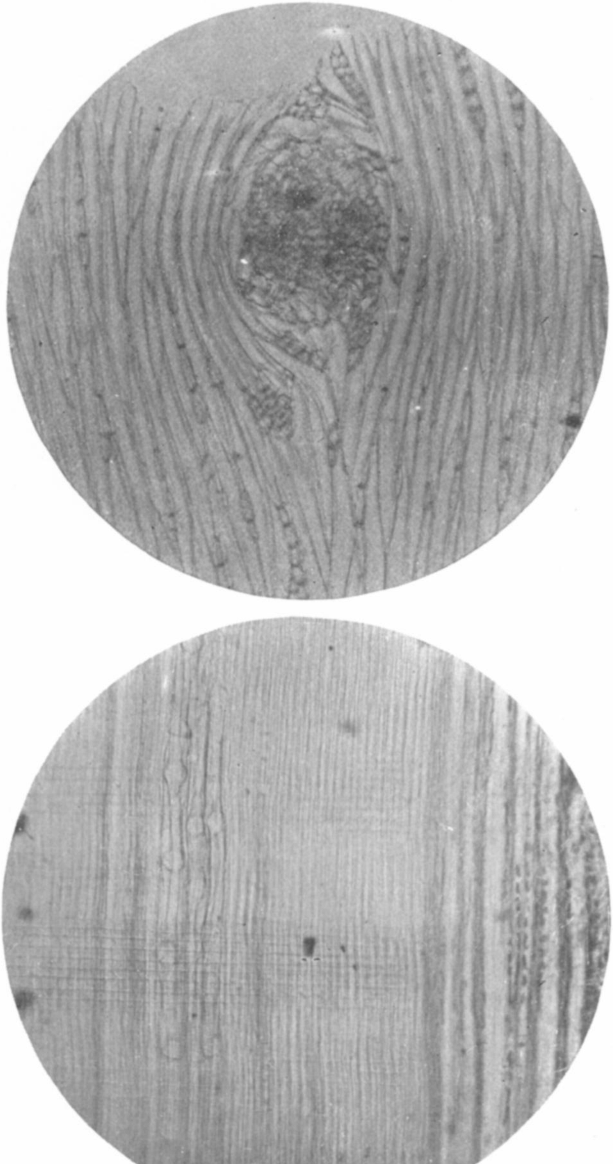

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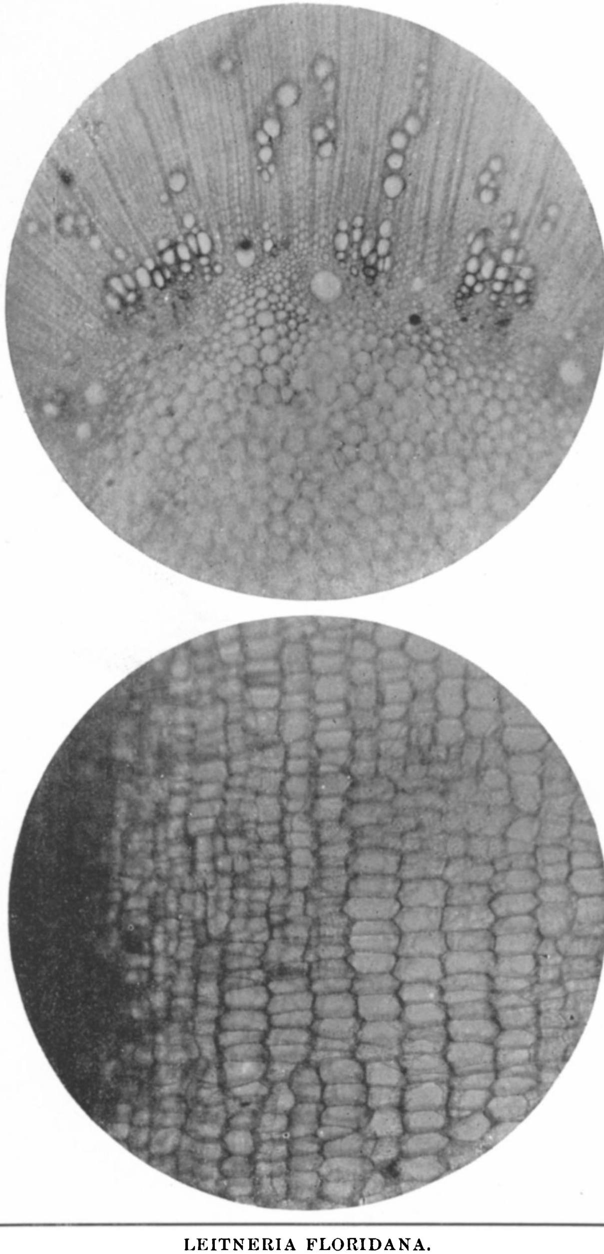

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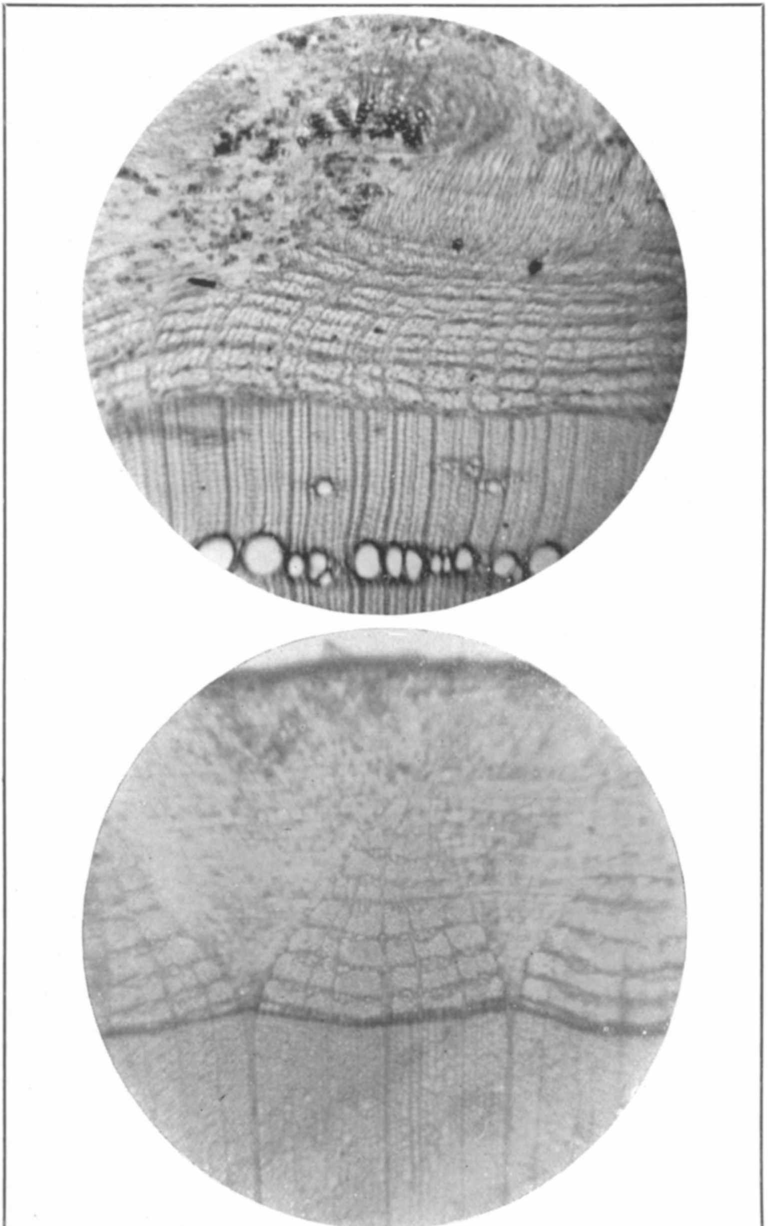
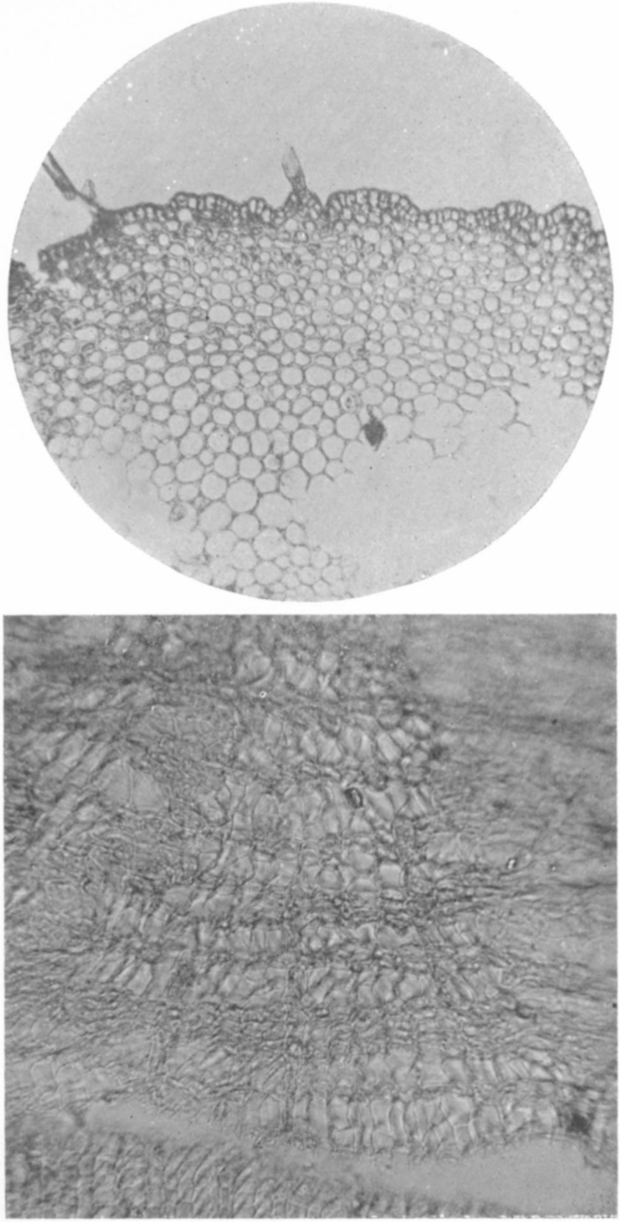


LEITNERIA AND TILIA.



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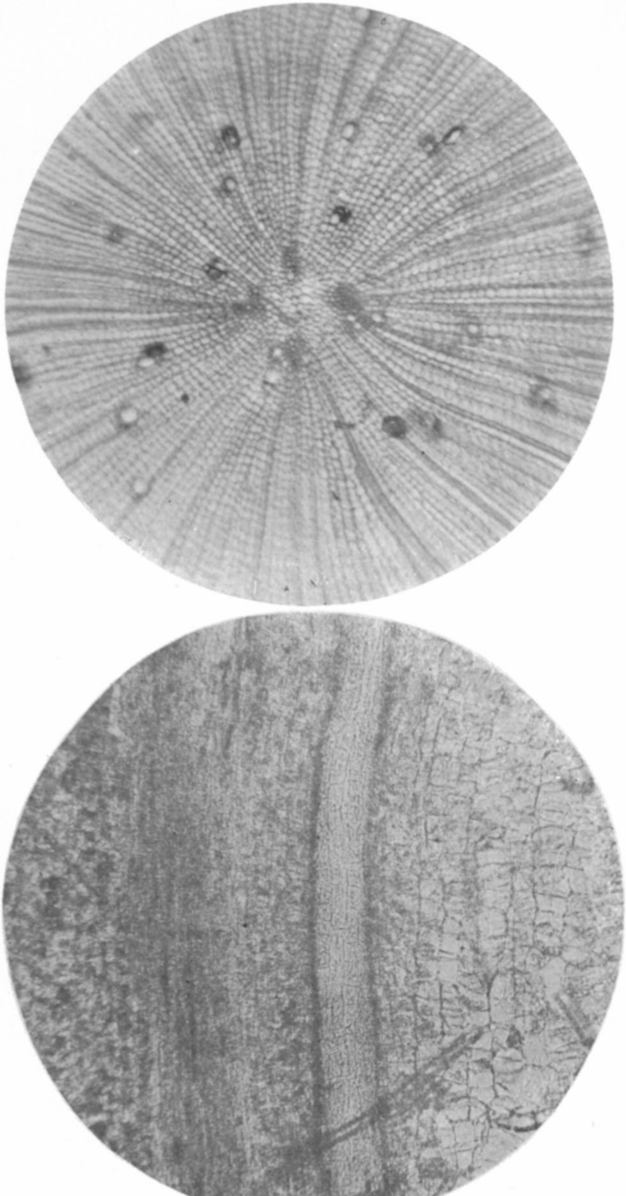

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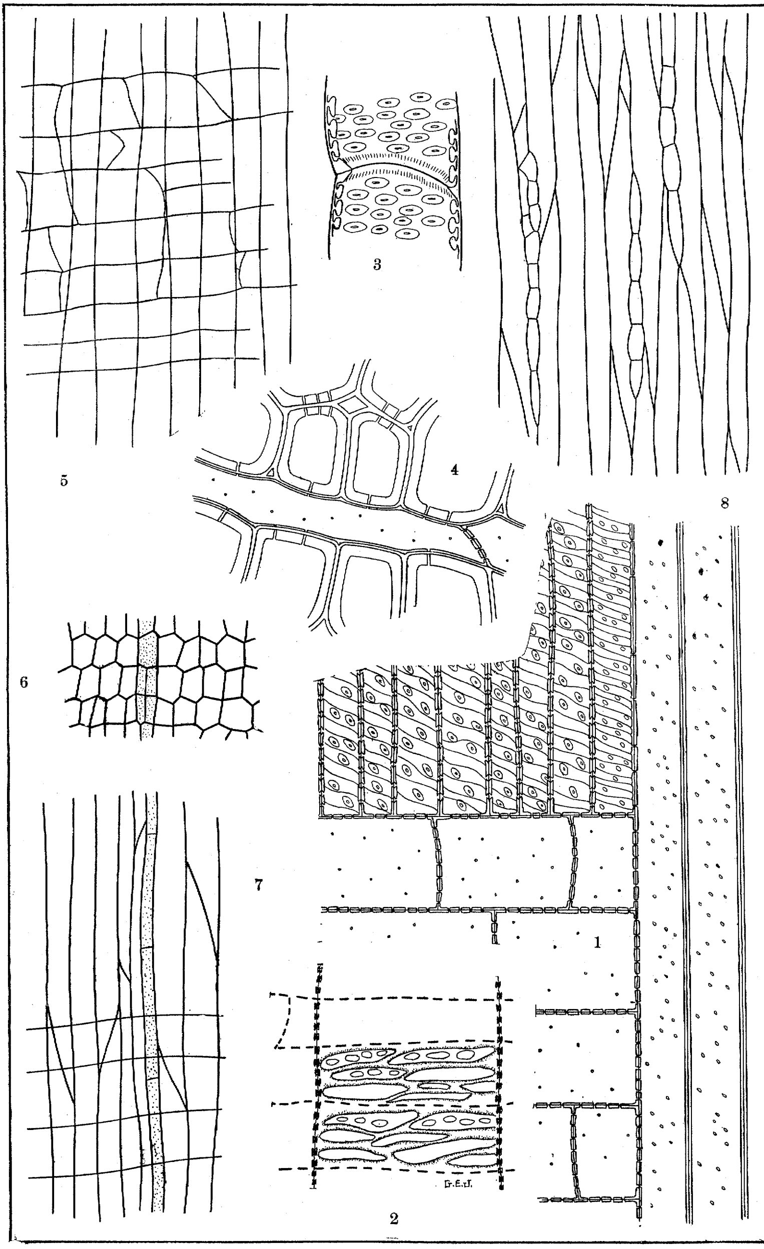

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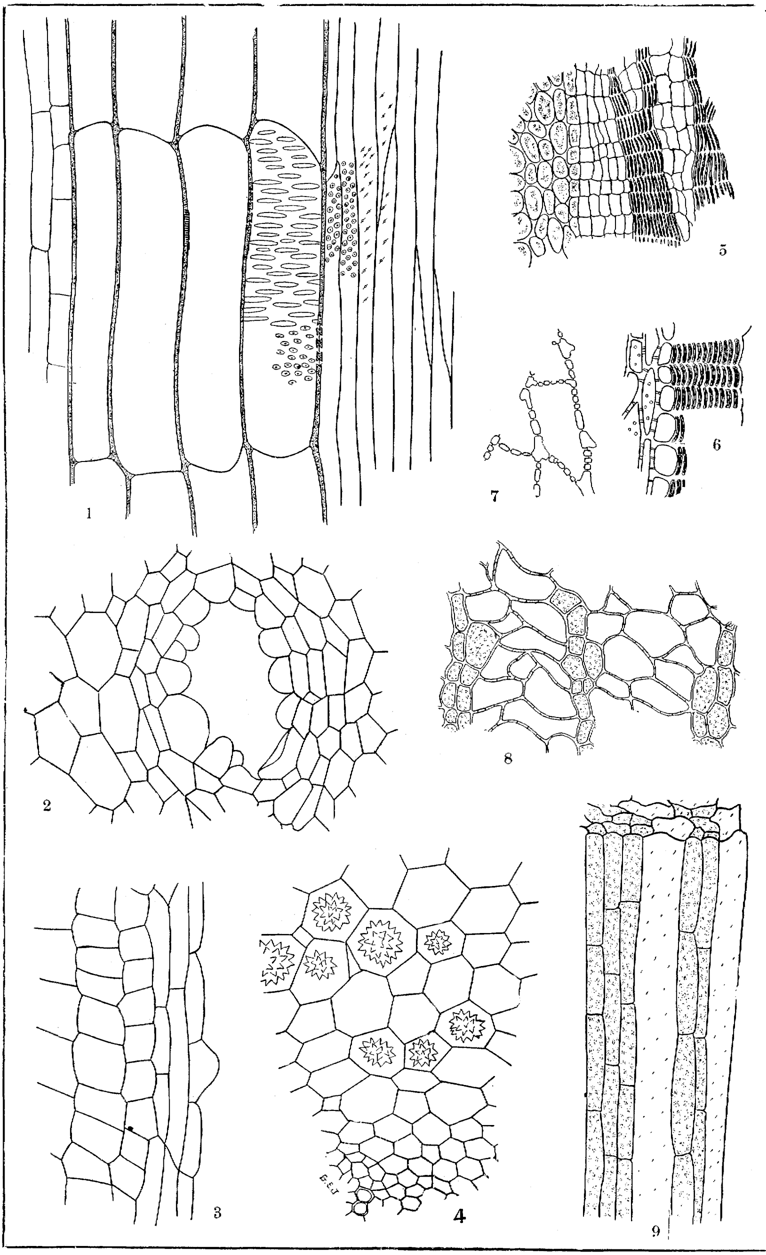

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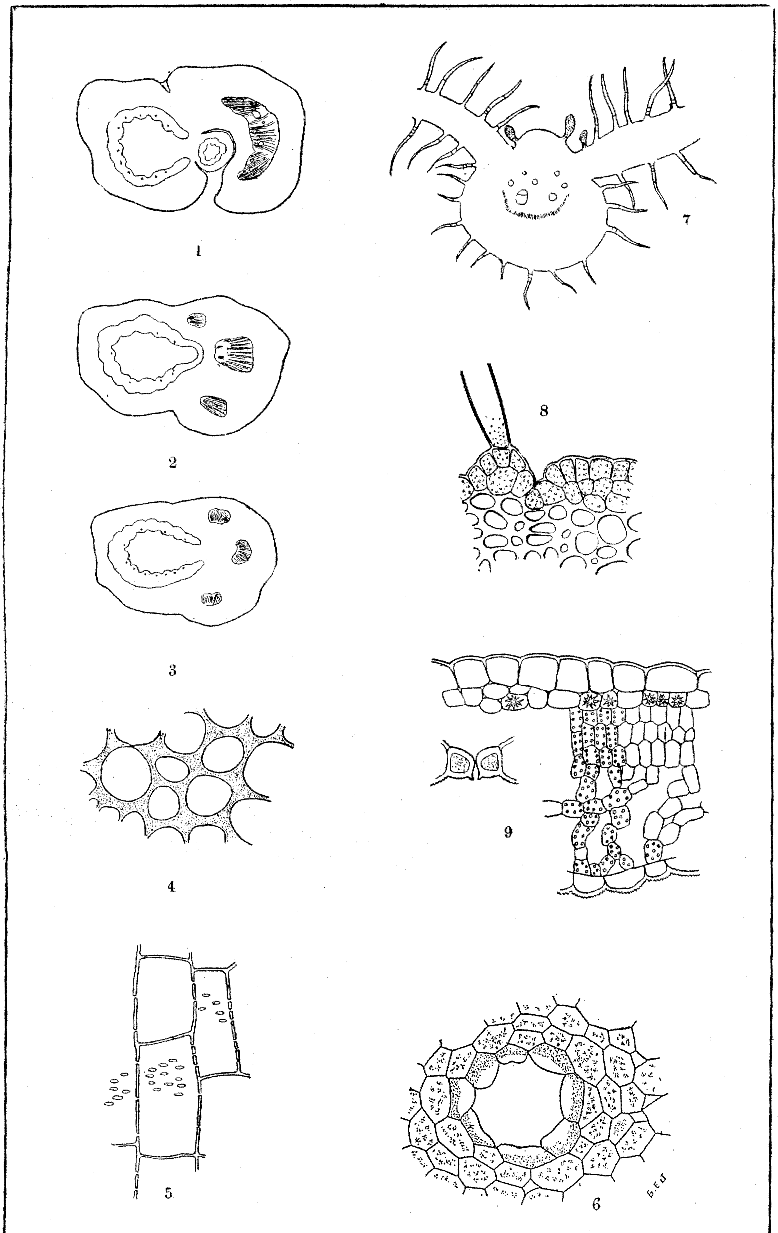

LEITNERIA FLORIDANA.